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Human Behaviour Representation - Definition

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Abstract

This paper is taken from the Final report of LTSS SAS-017 on Human Behaviour Representation in which A. v. Baeyer and J. Mylle gave this definition of HBR.

1 The importance of "Human Behaviour Representation"

The end of the Cold War has brought new military tasks and types of operations to NATO. These include regional contingency operations, Crisis Management and support of non-NATO missions (UN, PfP, WEU, etc). All these new types of missions have one newly emerging characteristic that implies a better modelling of human behaviour: they need methodologies to describe on various detail levels, how individuals and social entities (e.g. teams, groups) influence the course and outcome of military conflicts. Those emerging technologies will have a great impact on the implementation and on the military use of simulation systems in the future. Therefore, building better simulation systems and decision support tools, which include HBR, is of primary importance.

2 Definitions

2.1 Human behaviour

Human behaviour (B) is a purposive reaction of a human being (P) to an idiosyncratic meaningful situation (S).

Formally expressed: B= f (P,S). In words: the observed variability in behaviour is attributable to differences in the person's characteristics, to differences in the situation and/or to the interplay of both.

- Mathematically spoken: the variation in the measured behaviour can be explained by the variation in P, the variation in S and interaction between P and S (measurement error not taken into account). This definition implies that human behaviour:
- is a change from one state into another state (bodily and/or mentally);
- is always goal-oriented (but not necessary in a one to one relation)
- is a reaction to an external observable stimulus or to an internal covert stimulus,
- has three interrelated components: a cognitive, a psycho-motor and a socio-affective component

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- is an integration of several physiological and mental processes
- is individualised because each individual interprets the objective characteristics of the situation;
- is neither necessary „rationale“ nor the most appropriate reaction under given circumstances.

2.2 Representation

Representation means mapping (f) characteristics of empirical phenomena (P_e) into values of parameters in an artificial world (P_a). Thus a representation is determined by $\{P_e, P_a, f\}$.

This means that we need a (formal) system to describe P_e P_a and the mapping “function” f.

It must be stressed that mapping does not necessarily mean mimicking or portraying. For example, a plane that flies does not mimic the behaviour of a flying bird.

2.3 Model

A model is a simplified representation at a conceptual level of (a part of) the real world and/or the way it behaves, that suffices to make some deductions concerning the real world and/or it’s functioning. A model consists of components and the relationships between those components, which are generally cause-effect relationships. A model can be visualized in some graphical form.

For example, the three stage-model of memory (here rendered in its oversimplified form).

The graph below means that information that is kept by receptors is temporary stored in the sensory memory, is then transferred to the working memory, and after elaboration in this part, is permanently stored in the long term memory. Furthermore, information can be retrieved from the long term memory by the working memory (and then used for some behavioural purposes).

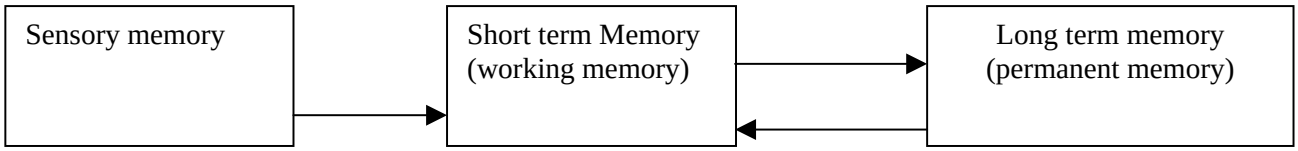


Figure 1: Example of a Model

Essential characteristics of a model are:

- Reduction of the complexity of the real world
- Highlighting what is considered as essential or important
- Transparency of the relationship(s) between the components
- Putting the representation in a certain perspective, based on the choice of the components and the relationship between components
- Productivity: models allow for the discovering of (working) hypotheses, for new insights at a certain level of quantification, for the verification of the impact of changes (by changing

starting values, by adding or dropping components and/or relationships: cfr path analysis; e.g. LISREL).

A model implies that:

- A choice must be made which characteristics will enter the model and which not
- Therefore, one or more selection criteria are needed (which define the perspective)
- Characteristics are to be reflected in variables that can be quantified

In the context of this LTSS the notion “model” does NOT refer to the physical device that shows how something works in reality (e.g. a model of the wings of a plane and the air streams around it) nor to the notion as defined in social learning, i.e. the person whose behaviour is mimicked.

Aspects of modelling human behaviour

- Given that human behaviour is purposive, not only the behaviour itself must be modelled but also the goal, which has to be converted in a *SMART objective* (**S**pecific, **M**easurable, **A**cceptable, **R**ealistic, **T**imed).
- This objective is the touchstone in determining what is the optimum behaviour under the given circumstances.
- In its most simple expression modelling behaviour means: determining initial values for P and S (input), run a process (throughput) which lead to an outcome (output); i.e. a change in P and/or S.
- The model requires a “level of behavioural analysis”:

A single action A contingent series of actions A series of actions executed in parallel	by a	an individual team an organisation

HBR modelling relies, as to the content of the models, on:

- Military experience
- Findings of human science research

The latter defines and structures, using established terms and theories, all relevant types of human behaviour. There are additional concepts that should be used as in for any further discussion and HBR science development. These concepts are:

- Individual
- Team
- Group (small group and large group)
- Organisation
- Crowd
- Public opinion (shaped by the media)

The basic concept is that of the individual.

Team, group, organisation and crowd are specific collections of individuals, which are defined according to different behavioural goals and interactions (both within the collective entity and as a collective entity interacting with others).

As for public opinion see Chapter 4 Section 4.2.1.

The scientific task with respect to the individual, team etc is to find and define the specific goals and interactions of the individual and of each collection of individuals, thus specifying what goals and interactions:

- build a military team from few skilled individuals
- make a small or a big group under certain special conditions
- create or change an organisation
- constitute a crowd, when many people suddenly behave in a uniform manner.

The task of modelling individuals, teams etc is

- to take the typical behaviour expressed in goals and interactions
- to put quantitative measures on the internal and external behaviour of the respective entity.

So far the characteristic behaviours that differentiate a team from any smaller or larger group or organisation or crowd have not been elaborated to the point where they can be used for modelling in a military context. Therefore, the first scientific endeavour is to collect on a systematic and scientifically accepted manner this body of knowledge, which can then be used by for modelling purposes.

- For each characteristic (= variable) a scale of measurement1 has to be determined and "baseline", i.e. an initial parameter value.
- A distinction has to be made between trait and state:
- a *trait* is a covert cross-situational and cross-temporal stable characteristic of a person but which expression is modulated by the perceived situation.
- A state is a condition not manifesting any marked change with respect to some quality or property.

For example, a person who shows often anxiety in his behaviour in different circumstance is an anxious person. This person is characterised by anxiety as a trait.

A person who is rarely seen anxious but has been confronted with a traumatic event is temporary anxious. This person is in a state of (intense) anxiety.

[1] A scale is the triple {U, N, f} in which U stand for the observed variations in the empirical phenomenon, N for the numerical values that are assigned to the observed "states" of the empirical phenomena using a function f.

2.4 Simulation

Simulation means:

- A method to implement a model in some environment and/or in a device, which may be totally or partially artificial (instead of real).
- A technique for analysing, testing, evaluating the effect of some values of the parameters of the model on other parameters. For example, a decision making process (e.g. choose a tactical plan among three alternatives) can be simulated on a computer, using some algorithm (among others, a decision tree).
- Using a tool (a simulator) for instruction or training purposes, e.g. flight simulator.

The following categories of simulation are used commonly in the NATO context/language of Modelling & Simulation:

Live simulation: real humans operate real equipment in a real environment except for some parts or aspects (e.g. OPFOR is not a real foe but a unit that acts as enemy; blank ammunition or hit/kill indicators instead of wet ammo; terrain is a training camp or a civilian area but not the operation zone)

Virtual simulation: real humans operate simulated equipment in a simulated environment (e.g. Computer Assisted (Command Post) Exercises; a pilot in a flight simulator).

Constructive simulation: simulated people (or units) operate simulated equipment and/or behave in a simulated environment. The intervention of real humans is limited to "initialise" the simulation run.

2.5 Instruction/learning

During instruction, a person learns a *new* cognitive, psychomotor or socio-affective "item" relevant to the organisation he is part of. Instruction takes place in a specific environment such as a school. Instruction is given by qualified personnel who are required to show the optimal behaviour and is thus better skilled than the trainee.

Learning in this sense, is defined as a long lasting desired behaviour modification under the influence of the repeated exposure to adequate stimuli. The learning process is (constantly) monitored by the instructor. The behaviour of the trainee is corrected on the spot. Feedback is procured during and after the training process.

E.g. an officer learns how to write an operations order for his subordinates, a soldier learns how to aim and fire a weapon, a new formed squad/crew learns what cohesion means to their functioning as a group.

2.6 Training

Training means to *repeat* a learnt behaviour in order to enhance the performance, or to internalise a norm, or to develop an attitude in a rather simplified environment. For example, a pilot is trained in applying flight procedures (in a simulator); discipline is trained throughout different situations, which require obedience to the established rules. Training does not differ from instruction with respect to the trainer/trainee interaction.

2.7 Exercise

An exercise aims at using what has been learned and trained but now in a less or more real like situation. In an exercise real people use real means in a real environment. For example, command post exercises; or full troop exercises live firing exercises in battle runs.

An exercise is controlled by an observer-controller (or a coach) who does not intervene in the course of action, but who is responsible for detailed after-action review. Moreover, the observer is not necessary better skilled than the people who are exercising.

2.8 Operation

Operation refers to real life (military) activities in order to realise a given mission. For example, the deployment of a task force, a brigade attack, peace keeping as a particular case of peace support operations.

2.9 Performance

Performance refers to the behaviour itself or its result/outcome in one of the following forms:

- Executing and finishing a certain task. For example, fire until hit.
- A numerical expression related to the behaviour. For example, defend a position during 4 hours
- Expression of the competence, moderated by some personal and/or situational variables. For example, physical performances under bad weather conditions (too cold, too warm) are lower than under good weather conditions.

2.10 Competence

Competence means the best possible behaviour of a given person with respect to certain ability for a particular job or vocation. Competence is a higher order notion for a series of performances that meet high standards. For example, a competent leader is a leader who is often successful in conducting operations (of different kind).

2.11 Optimal behaviour

Optimal behaviour is the best possible performance given under the circumstances; i.e. taking personal and situational constraints in to account; thus: B=f (P,S). This means also that an optimal performance is lower than or equal to the maximal performance (=competence).

2.12 Situational awareness

Situational awareness is the result of the perception of a number of elements in the environment within a given timeframe and space, their meaning with respect to the mission at hand and their possible evolution in the near future that must be taken into account in determining one's own behaviour.

Situational awareness is multidimensional because it deals with spatial information (e.g. where is who/what), with information contained in the mission (e.g. what to do within which time interval), own means (e.g. "readiness" of crews) and available resources (e.g. which fire support).

2.13 Validation, Verification, Accreditation

- *Validation* means determining the degree to which a model is an adequate representation of the real world (or a part of it) for the purposes it has been conceived for.
- *Verification* refers to the process of determining to what extend the implementation of a model corresponds to the design specifications determined by the customer and of providing the proof that the model runs (as its has to run).
- *Accreditation* is the official certification that a model or simulation is acceptable for use with respect to its purpose(s).

3 A Concise Structural Approach of HBR as a Framework

This section tries to give a global approach of HBR in military applications. However, a global theory cannot be the goal of this LTSS and must be postponed, when more information about the practical use of HBR for any field is available. Therefore, we have to limit an approach to a framework.

3.1 General Approach

The concise theory must avoid two fallacies:

- on the one hand to be too short and therefore trivial
- and on the other hand to be too scientific and lengthy.

This dilemma will be avoided by presenting a logical deduction and phenomenological description of those human *behaviours*, which are essential in military operations (including CRO) and the way they should be represented for analysis, training and simulation.

By logical deduction it is understood that the theory is coherent in itself, and not just an arbitrary collection of abstract statements.

By phenomenological description a description is meant, which focuses on typical and relevant events and describes them as close to (military) common sense as possible.

3.2 Objects of HBR-Theory

The ultimate goal of HBR is (as this is the case in every military simulation), to represent behaviour that is *typical and relevant* in military operations. Relevant is every human behaviour, which is decisive for the mission success. But in order to make it the object of a theory and therefore the object of well elaborated models and simulations, the human behaviour must be "reduced" to certain "system simplifications".

What is the "level of detail" that must be employed to describe the human *behaviour*?

The level of detail of a rough task analysis but reduced to general mental (i.e. cognitive, psycho-motor, social and physiological) functions (examples see below).

What is relevant for the *representation* of behaviour?

Every behaviour that is needed in analysis, training and simulation is considered as relevant.

3.3 Elementary Behaviours (mental functions)

The following is a taxonomy, which lists mental functions in a systematic way appropriate for modelling.

- Actions – Observable behaviour in the outside world
  - Interactions with real objects and real environment - physical skills (e. g. driving a car, digging a hole)
  - Symbolic interactions (e.g. communication by speech, in documents by gesture)
  - Social interactions (e. g. speaking to another person)
    - Interpersonal relations (with superiors, subordinates, colleagues)

        - Group dynamic influences (small group effects; e.g. cohesion)
        - Organisational influences

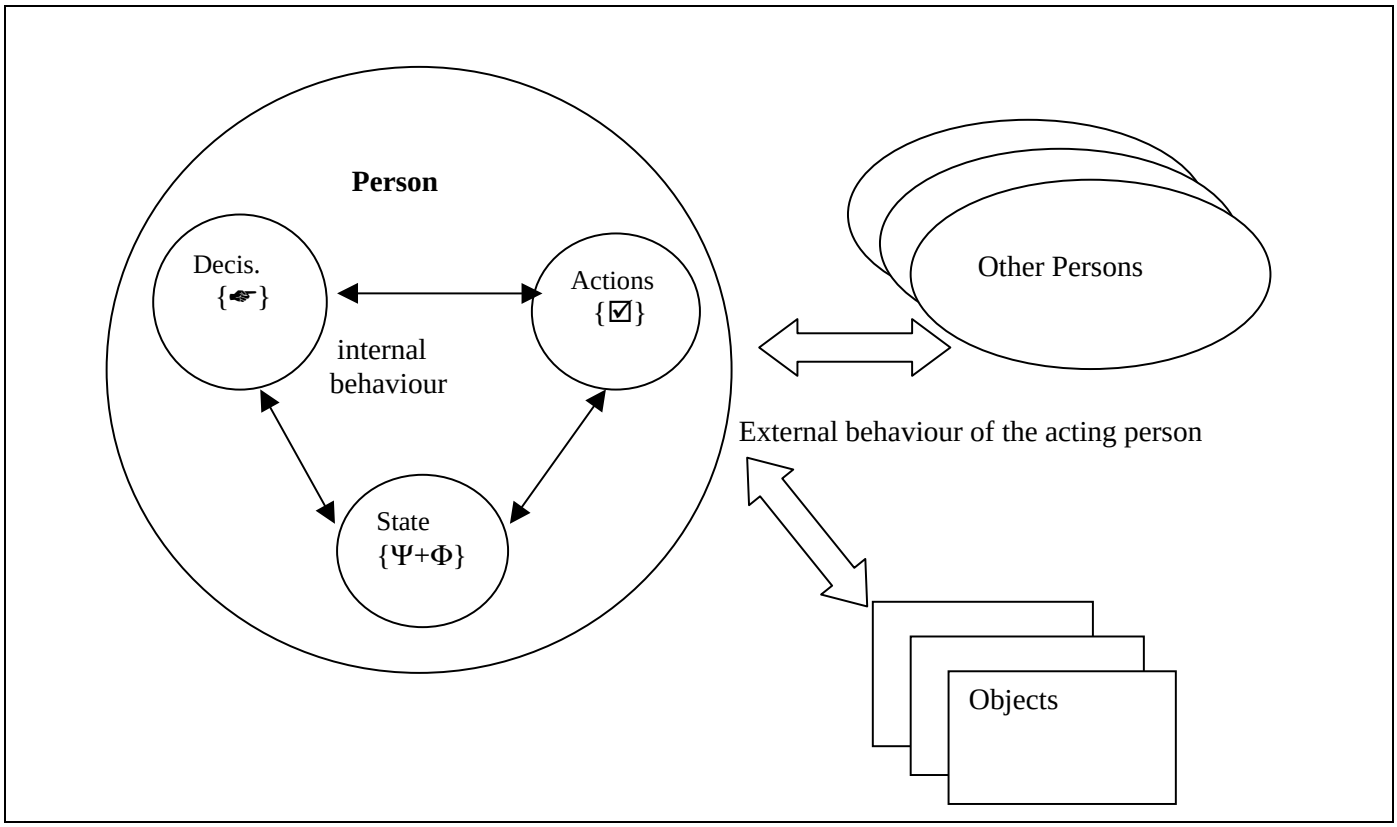
- Decisions – not directly observable behaviour within the person – making up one's mind.
    - Situational awareness (e. g. observing an area)
    - Information collection (e. g. map reading)
    - Information processing – from sensory input to mental models (e. g. identifying an object as foe)
    - Schemata (e. g. knowledge, skills)
        - Declarative knowledge
        - Procedural knowledge and skills
        - Meta-cognitive skills (control of behaviour, evaluation)
    - Deciding for action (e. g. shooting to a foe object, giving an order to shoot)
- Psychical and physiological traits / states
    - Age
    - Values (e. g. personal standards, cultural values, beliefs, attitudes)
    - Moods / emotions (e. g. anxiety)
    - Motives (e. g. high performance motive)
    - Alertness / vigilance (e. g. high vigilance)
    - Stress (e. g. loss of sleep, heavy workload)
- Dynamic changes of behaviour
    - Learning and Instruction (slow)
    - Traumatic experience (quick)
    - Duration of stress

For the scope of this paper it is sufficient to use this simple taxonomy. It can be used for three purposes:

- to describe a global structural concept of the interrelationships between the behaviours (human behaviour "model")
- to establish a list of compound behaviours
- to evaluate the feasibility of special elementary human behaviour model
- to define the different kinds of representation for analysis, training and simulation.

3.4 Compound Behaviours

No single behaviour type exists by itself. All types are always combined and have to be represented at least together with some of the other types. The global behaviour model, therefore, serves the purpose of identifying the interrelationships of the behaviour types. Internal behaviour (within the person) and external behaviour (towards other persons and with objects in the environment) are combined into compound behaviours. See the following picture.



Picture 2: Person and its behaviour in an environment

➢ Objects and persons provoke decisions and actions.
➢ Motives influence the choice of individually available schemata.
➢ Schemata influence decisions.
➢ Decisions make persons act.
➢ Age values, moods, alertness and stress moderate decisions.
➢ Age values, moods, alertness and stress moderate directly actions.
➢ Actions change values, moods, motives, alertness
➢ Actions change decisions.
➢ Decisions change values, moods, motives.
➢ Objects, persons and stress cut off the decision-making processes.

Table 1: Internal compound behaviour

➢ Actions change objects.
➢ Actions influence other persons.
➢ Other person's actions and objects of the environment make persons change their psychical and physiological states.

Table 2: External behaviour

3.5 Data Sources

Every behaviour produces different data. The data can be classified into two groups:

- Directly accessible data, which are subdivided into
  - measurable and observable data {m+o}
  - only observable data {o}
- Data that must be constructed indirectly by theories {c}.

Applying this simple data taxonomy to the behaviour types, it can be seen, whether it is (relatively) easy to build models about the behaviours in question (on model building in HBR see below):

- Directly accessible data {m} and {o} make model building easier; many models do already exist and are used
- Constructed data make model building difficult.

The reason lies in the validation and accreditation of the data. Directly accessible data can by verified through objective methods and the corresponding theory. Constructed data are entirely based upon the validity of the theory.

Directly accessible data can be sub-divided into:

- Observable data at a high level of measurement; i.e.
  - on an interval scale. For example: body temperature, precision of aiming at a target.
  - on a ratio scale. For example: speed of movement, estimation of the distance to a target.
- Observable data at a low-level of measurement, i.e.
  - at a nominal level or classifying objects. For example, friend or foe, identifying a object as a main battle tank
  - at an ordinal level or ordering objects with respect to a certain criterion. For example, "intensity" of threat of different enemy manoeuvres.
  - at the hyper ordinal level or comparing differences between (two) sets of two objects. For example, different balances of forces.

Unobservable data refer to psychological constraints. The way they are "operationalised" i.e. made observable. The process of operationalisation determines also their level of measurement.

For example, intelligence is made observable through the responses to an intelligence test and can be expressed in an intelligence quotient IQ (which is at the interval level). For example, group cohesion can be expressed through a ranking of the co-workers by each of the group members. Using multi-dimensional scaling these rankings can be converted into a map with distances between the members. The greater the distances the less cohesion is.

Complex constructs, for example combat readiness –involving several domains of human behaviour (i.e. cognitive, motor and/or socio-affective) constitute a specific challenge for modelling because the whole is more and something other than the sum of its components. Therefore, it is suggested to approach such constructs in a holistic way rather than in an analytical way.

Behaviours	**Data**
Actions {☑}	
Interactions with real objects and real environment (e. g. driving a car, digging a hole)	m+o
Symbolic interactions (e. g. writing)	m+o
Social interactions (e. g. speaking to another person)	m+o
Decisions {☛}	
Situational awareness (e. g. observing an area)	o
Information collection (e. g. asking an expert)	o
Information processing (e. g. identifying an object as foe)	o
Deciding for action (e. g. shooting to a foe object, giving an order to shoot)	m+o
Psychical and physiological states {Ψ+Φ}	
Values (e. g. cultural values)	c
Moods / emotions (e. g. anxiety)	c
Motives (e. g. high performance motive)	c
Alertness / vigilance (e. g. high vigilance)	m+o
Stressors (e. g. loss of sleep, heavy workload)	m+o
Schemata (e. g. knowledge, skills)	c
Dynamic changes of psychical and physiological states {Δψφ}	
Learning (slow)	c
Traumatic experience (quick)	o
Duration of stress	m+o

Table 3: Matrix of elementary behaviours and the related data sources

4 Model Building in HBR

Models of human behaviour are always models of compound behaviours. It is still uncertain, whether an all-embracing model of *the* Human Behaviour is feasible and necessary for military simulation. The following matrix gives an overview on the feasibility models. Every compound behaviour is analysed as to whether models are

- Easy to develop, even if they do not yet exist {e}
- Difficult to develop, even if they already exist {d}
- Impossible to develop {i}.

	Feasibility of Model Building	
Behaviours	Easy	Difficult
Objects and persons provoke decisions and actions.	e	
Motives influence the choice of individually available schemata.		d
Schemata influence decisions.		d
Decisions make persons act.	e	
Values, moods, alertness and stress moderate decisions.		d
Values, moods, alertness and stress moderate directly actions.		d
Actions change values, moods, motives, alertness		d
Actions change decisions.		d
Decisions change values, moods, motives.		d
Objects, persons and stress cut off the decision making processes.	e	
Actions change objects.	e	
Actions influence other persons.		d
Other person's actions and objects of the environment make persons change their psychical and physiological states.		d

Table 4: Matrix of behaviours and the feasibility of model building

Conclusion: There is no human behaviour, which cannot be made the object of a model. However, the majority is difficult to model and relies mainly on theories of the elementary behaviours (mental functions), which themselves are difficult to validate.

5 References

Dompke, U., Scheckeler, K., Final Report on Long Term Scientific Study (LTSS/SAS-017) on Human Behaviour Representation (HBR) Technology, RTO-TR-047, AC/323(SAS-017)TP/25, Brussels, 2001

Human Behaviour Representation Definition

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Topics

- **Definitions**
- **A Concise Structural Approach as a Framework**
  - **General Approach**
  - **Objects of HBR Theory**
  - **Elementary Behaviours**
  - **Compound Behaviours**
  - **Data Sources**
- **Model Building in HBR**

Notes for Slide 2

The **Logical or Functional Perspective**. This view focuses on the logical or functional interrelationship of the CAX System Components and constitutes the **Functional Architecture of the CAX System**. The Functional CAX Architecture described in 1 is derived from military operational needs and it is not constrained by any system topology or other CAX System Implementation considerations.

The **CAX System Topology**. This view defines and evaluates available options for providing the CAX functionality. As the first step in this process, six options are identified, each with a different degree of integration of CAX with CCIS and with a different degree of distribution of the CAX functionality itself. The second step is then to compare the CAX Architectural Options and come up with advantages and disadvantages of each of them. This analysis, provided in Section 2, is based on the Functional Architecture as well as on a set of assessment criteria such as User Satisfaction, Implementation/Operation & Maintenance Cost, Security, Technological Trends and Flexibility.

Notes for Slide 2 (Continued)

The **CAX System Physical Architecture** describes hardware and software components and their interrelationships for the CAX system. In future CCIS, as in other modern information systems, this physical architecture will not play the role it is playing today. New technologies available to implement functions on distributed systems and global data links will make it possible to concentrate on the functional and topological design of the systems. Even changes from one physical architecture to another regarding the distribution of functions in a network will be no major problem and will give the opportunity to decide on topological architectures as described in chapter 2 in accordance with the exercise requirements. Chapter 3 introduces the discussion on possible implementation options for the different topological CAX architectures.

HBR Definition

Human behaviour (B) is a purposive reaction of a human being (P) to an idiosyncratic meaningful situation (S)

Formally expressed: B= f (P,S)

In words: the observed variability in behaviour is attributable to differences in the person's characteristics, to differences in the situation and/or to the interplay of both.

Human Behaviour (I)

- **is a change from one state into another state (bodily and/or mentally)**
- **is always goal-oriented (but not necessary in a one to one relation)**
- **is a reaction to an external observable stimulus or to an internal covert stimulus,**
- **has three interrelated components: a cognitive, a psycho-motor and a socio-affective component**

Human Behaviour (II)

- is an integration of several physiological and mental processes
- is individualised because each individual interprets the objective characteristics of the situation
- is neither necessary „rationale“ nor the most appropriate reaction under given circumstances

Representation

- **Representation means mapping (f) characteristics of empirical phenomena (P_e) into values of parameters in an artificial world (P_a)**

- **Thus a representation is determined by {P_e, P_a, f}**

Model

A model is a **simplified representation** at a conceptual level of (a part of) the real world and/or the way it behaves, that suffices to make some deductions concerning the real world and/or it's functioning.

A model consists of **components** and the **relationships between those components**, which are generally cause-effect relationships. A model can be visualized in some graphical form.

Characteristics of a Model

- Reduction of the complexity of the real world
- Highlighting what is considered as essential or important
- Transparency of the relationship(s) between the components
- Putting the representation in a certain perspective, based on the choice of the components and the relationship between components
- Productivity: models allow for the discovering of (working) hypotheses, for new insights at a certain level of quantification, for the verification of the impact of changes

Aspects of Modelling Human Behaviour

- **Given that human behaviour is purposive, not only the behaviour itself must be modelled but also the goal, which has to be converted in a SMART objective (Specific, Measurable, Acceptable, Realistic, Timed).**
- **This objective is the touchstone in determining what is the optimum behaviour under the given circumstances.**
- **In its most simple expression modelling behaviour means: determining initial values for P and S (input), run a process (throughput) which lead to an outcome (output); i.e. a change in P and/or S.**

Concepts in HBR Models

- Individual
- Team
- Group (small group and large group)
- Organisation
- Crowd
- Public opinion (shaped by the media)

General Approach

- **Logical deduction and phenomenological description of those human behaviours, which are essential in military operations (including CRO) and the way they should be represented for analysis, training and simulation**
- **By logical deduction it is understood that the theory is coherent in itself, and not just an arbitrary collection of abstract statements.**
- **By phenomenological description a description is meant, which focuses on typical and relevant events and describes them as close to (military) common sense as possible.**

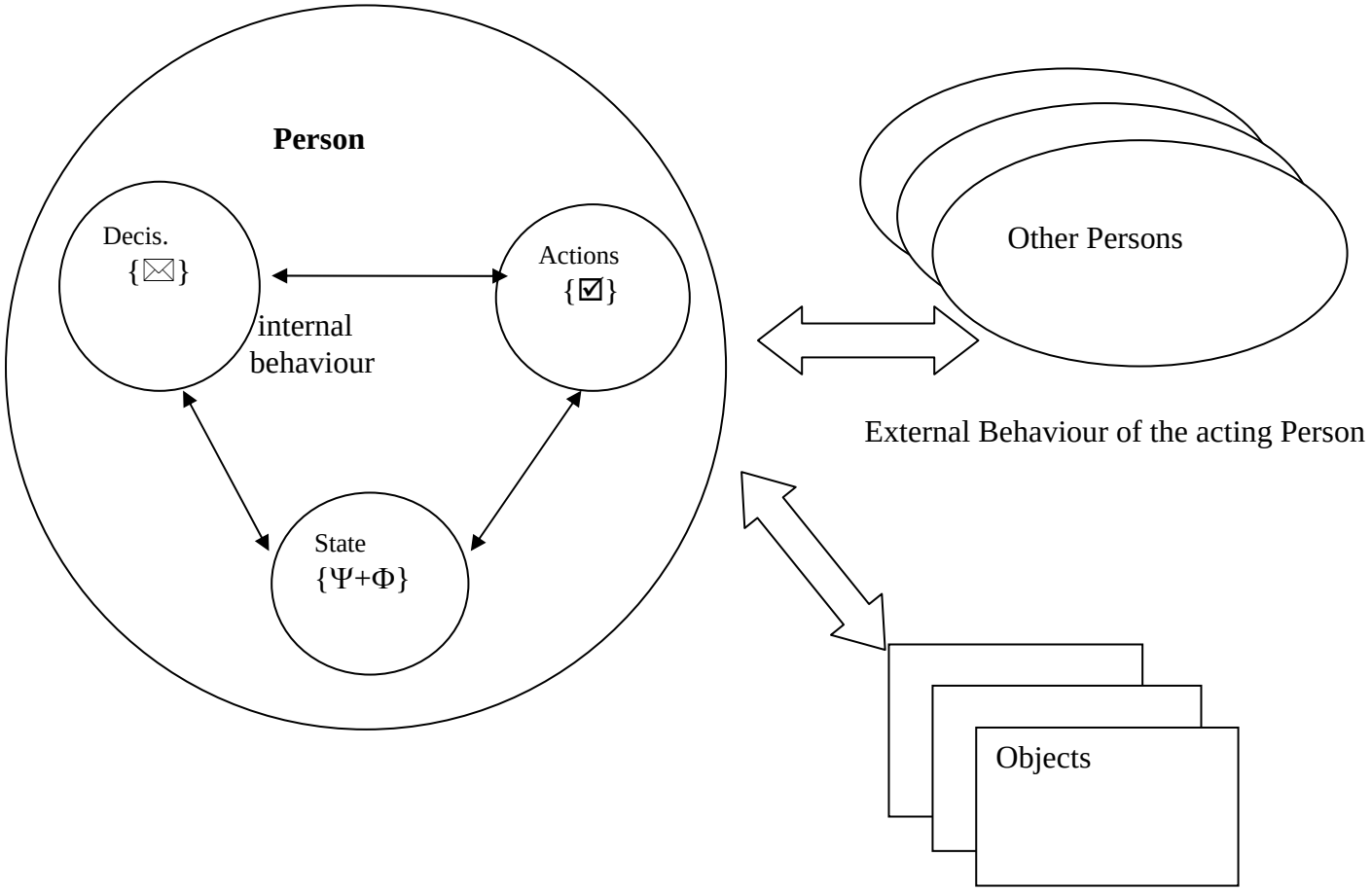
Objects of HBR Theory

- Ultimate goal is to represent behaviour that is typical and relevant in military operations
- Every behaviour that is needed in analysis, training and simulation and decisive for the mission success is considered as relevant
- The level of detail is equal to one of a rough task analysis but reduced to general mental (i.e. cognitive, psycho-motor, social and physiological) functions

Elementary Behaviours

- **Actions – Observable behaviour in the outside world**
- **Decisions – not directly observable behaviour within the person – making up one's mind**
- **Psychical and physiological traits / states**
- **Dynamic changes of behaviour**

Compound Behaviours



Data Sources

- **Directly accessible data, which are subdivided into**
  - **measurable and observable data {m+o}**
  - **only observable data {o}**
- **Data that must be constructed indirectly by theories {c}.**

This slide has been deliberately left blank

Diapositive intentionnellement blanche